b-jet and non-prompt D-meson correlation in hard QCD events

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Motivation

- Through the b-jet and B hadron correlations with B hadron within the leading b-jet jet cone and B hadron within the away-side b-jet jet cone,
    - understand the b->B hadron fragmentation process when comparing to di b-jet correlations (https://indico.bnl.gov/conferenceDisplay.py?confId=2678).
    - Extend the z_j scale to lower p_T region but the cost is the branching ratio and decay smearing of b->B->D^0.
    - help understand the b quark energy loss in Au+Au collisions.
- Use non-prompt D^0 to tag B hadron.
- The D meson reconstruction studies allows the search of prompt D meson tagging jets, which will provide the information about c-jets and help understand the mass/flavor dependent parton energy loss.
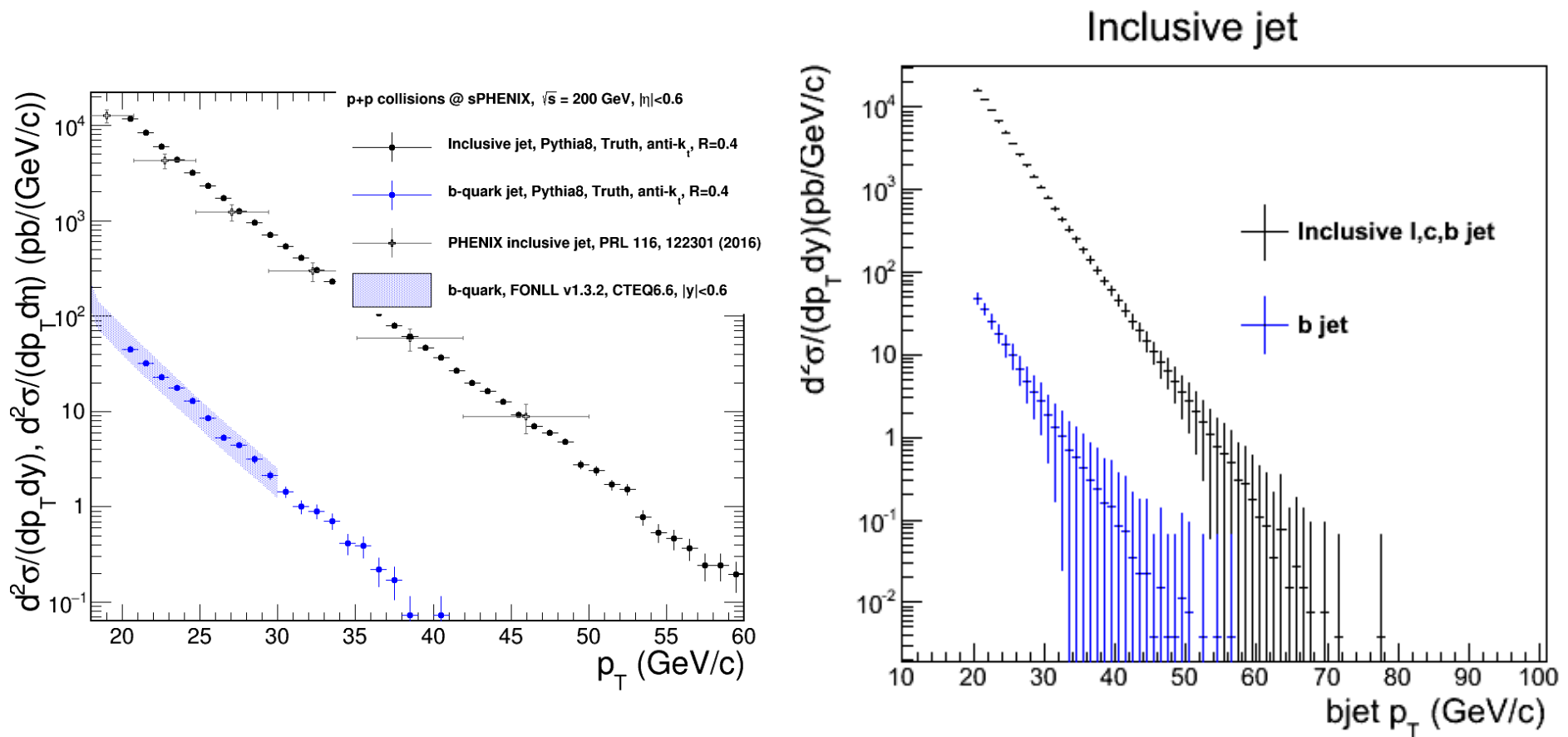
PYTHIA8 simulation

- Run 18M PYTHIA8 Hard QCD simulation events.
- Only look at events contain leading jets with $p_T > 20 GeV/c$ and within $|\eta| < 1.0$.
- Check the away-side B-meson and D-meson z_j.
- Look at all away-side kaons and pions with $p_T > 0.3$ GeV/c and displaced vertex.
- For kaons and pions, form pairs between them with opposite charge sign and only when the differences between their z decay vertex is less than 500 μm.

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D-meson

b-jet

B-meson

Leading b-jet

Away-side
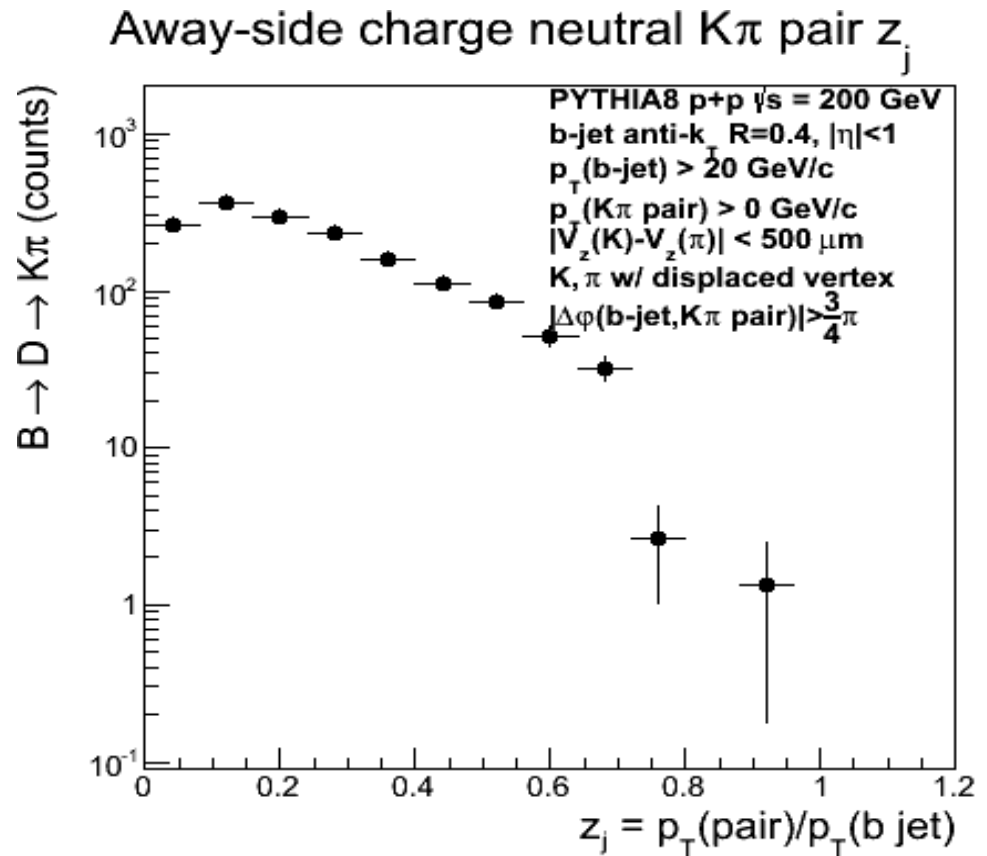
$\pi^\pm$ $K^\pm$

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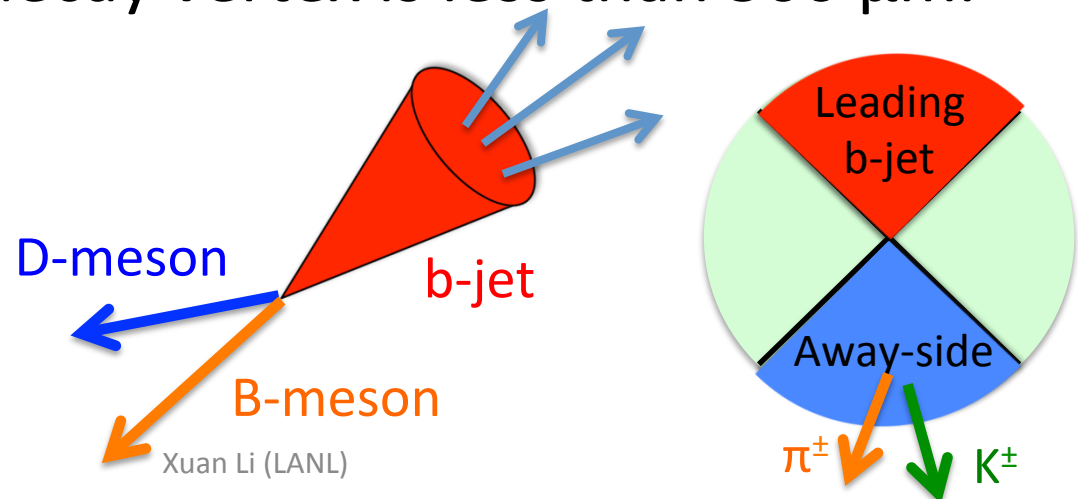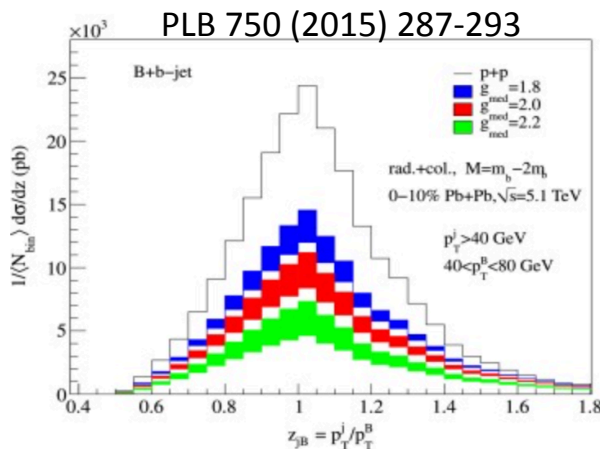
Cross-check with the b-jet cross section in MVTX pre-proposal

- My PYTHIA MB inclusive jet cross section (right) is comparable with the MVTX pre-proposal figure 5 (left).

p+p b-jet and non-prompt D^0 projection

- Assume b-jet tagging efficiency is 0.5 and its purity is 1. The purity needs further studies.

- Assume non-prompt D^0 efficiency is 0.6.

- For p+p, assume the integrated luminosity is 175 pb^{-1}, and this number could be doubled for more than 4 year data taking periods.

- Background is not evaluated and needs further studies.

Away-side charge neutral $K\pi$ pair z_j

PYTHIA8 p+p $\sqrt{s}$ = 200 GeV
b-jet anti-k_T R=0.4, $|\eta|<1$
p_T(b-jet) > 20 GeV/c
p_T($K\pi$ pair) > 0 GeV/c
$|V_z(K)-V_z(\pi)|$ < 500 μm
K, π w/ displaced vertex
$|\Delta\varphi$(b-jet,$K\pi$ pair)$|>\frac{3}{4}\pi$

$B \rightarrow D \rightarrow K\pi$ (counts)
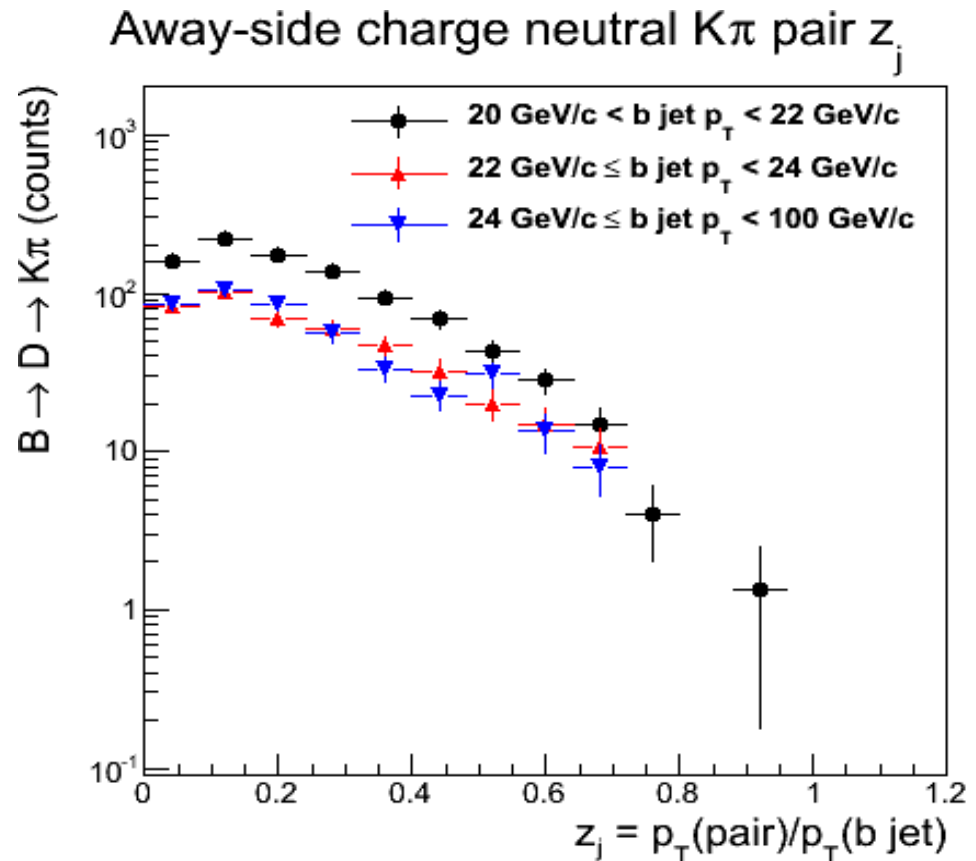
$z_j = p_T$(pair)/p_T(b jet)

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Away-side charge neutral $K\pi$ pair z_j

Legend:
- 20 GeV/c < b jet p_T < 22 GeV/c
- 22 GeV/c $\leq$ b jet p_T < 24 GeV/c
- 24 GeV/c $\leq$ b jet p_T < 100 GeV/c

y-axis: $B \to D \to K\pi$ (counts)

x-axis: $z_j = p_T(\text{pair})/p_T(\text{b jet})$
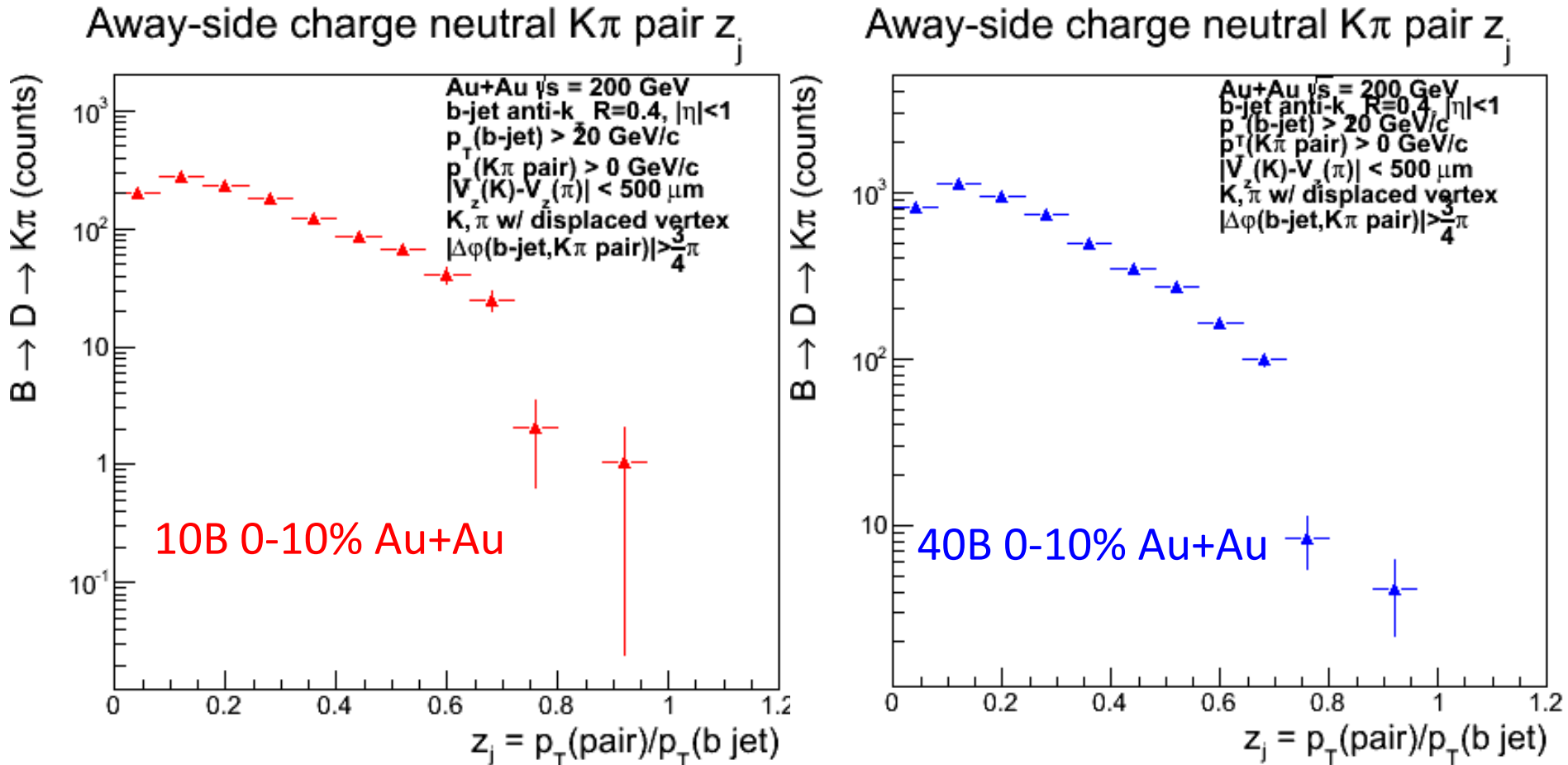
Au+Au Luminosity Projections

- Assume b-jet tagging efficiency is 0.5 and its purity is 1.

- Assume non-prompt D^0 efficiency is 0.6.

- Assume b-jet and non-prompt D^0 R_{AuAu}=0.6.

- For 10B 0-10% Au+Au collisions, the estimated integrated luminosity is:

$$L = N_{eve} \times N_{coll} / \sigma_{pp} = 10B \times 962 / 42mb = 229 pb^{-1}$$

- For 40B 0-10% Au+Au collisions, the estimated integrated luminosity is 916 pb^{-1}.

Au+Au b-jet and non-prompt D^0 Projections

- Projection in 10B (left) and 40B(right) 0-10% Au+Au events.

Away-side charge neutral $K\pi$ pair z_j

Au+Au $\sqrt{s}$ = 200 GeV
b-jet anti-k_T R=0.4, $|\eta|$<1
p_T(b-jet) > 20 GeV/c
p_T($K\pi$ pair) > 0 GeV/c
$|V_z(K)-V_z(\pi)|$ < 500 μm
K, π w/ displaced vertex
$|\Delta\varphi(b\text{-jet},K\pi \text{ pair})|>\frac{3}{4}\pi$

10B 0-10% Au+Au

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$|\Delta\varphi(b\text{-jet},K\pi \text{ pair})|>\frac{3}{4}\pi$

40B 0-10% Au+Au

$z_j = p_T(\text{pair})/p_T(\text{b jet})$

Conclusions

- It is feasible to do the b-jet and non-prompt D^0 correlations at sPHENIX with TPC+INTT+MVTX tracking.

- Need to apply a more realistic R_{AA} projection for b-jet and non-prompt D^0 correlations which could be provided by theory calculations.

- Need to study possible cuts to enhance the signal to background ratio such as the pair DCA cuts.

- Need to think about online D^0 trigger development for both inclusive D^0 and correlation studies.

- Could apply similar method to tag prompt D^0 for the c-jet study.